# Mapping Of Collaborative Innovation Research: A Bibliometric Analysis

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## Abstract

Traditionally, organizations rely on their internal resources for innovation projects, right from idea generation and initial research and development, until implementation and commercialization processes. Nevertheless, organizations have come to recognize that they cannot rely solely on their internal resources to drive innovation, mostly due to the growing mobility of knowledge workers, shifts in customer preferences, budgetary limitations, and other internal and external challenges. They have started to work collaboratively with consumers, vendors, higher learning institutions, and other stakeholders in their innovation journey. Owing to the potential benefits it offers, collaborative innovation has not only attracted interest not only from practitioners and industry players, but also from academia. However, despite the development of research related to collaborative innovation, studies looking into research trends within this evolving area of study are still lacking. Therefore, this paper performed bibliometric analysis to provide insights into the scientific research on collaborative innovation. Drawing from a collection of 375 articles extracted from the Scopus database, descriptive analysis and clustering analysis were performed using Microsoft Excel and the Biblioshiny application to discover and visualize the evolution of research within this field. Several trends relating to productivity, citation, and research trends and clusters were identified. These findings provide important input towards understanding the nature of collaborative innovation research and future direction within this research field.

**Keywords:** Collaborative Innovation, Bibliometric Analysis, Biblioshiny, Scopus.

## Introduction

An idea, product or process can be considered an innovation if it is perceived as "new to an individual, a group of people or firms, an industrial sector, or a society as a whole" (1). For an organization, innovation is fundamental to its growth, success and survival (2, 3). Therefore, innovation activities are present in all economics sectors, as well as in public organizations and non-profit institutions (4). However, in the pursuit of innovation, organizations face several challenges. Among them are the increasing mobility of knowledge workers, and the rapid development of information and communication technologies (5, 6). This phenomenon contributes to inability of organizations to control their in-house knowledge resource, which form an important ingredient for innovation. Escalating the situation further are the rapid change of consumer trends and preference (5), shortened product life-cycle (6), financial constraints (7), calls for improvement in resource efficiencies, and societal and environmental concerns (8). In responding to these challenges, organizations have acknowledged that the conventional in-house-only approach towards innovation may not work and therefore have started to work collaboratively with external stakeholders in their innovation activities (9, 10). Collaborative innovation, which is defined as "the creation of innovation across firm (and perhaps industry) boundaries through the sharing of ideas, knowledge, expertise, and opportunities" (11), offers several advantages. It represents a progression towards a more interconnected and transboundary approach to innovation and is closely associated with broader innovation frameworks such as open innovation and co-innovation, which advocate for leveraging external knowledge and engaging diverse stakeholders in the innovation process (5). Through collaborative innovation with consumers, for example, business firms could anticipate the future trends of their market (12).

In addition, collaborating with various stakeholders could also provide organizations with access to other intangible resources such as skills, ideas, creativity, and authority, as well as tangible assets such as financial resources and physical assets that they lack internally (13, 14). Furthermore, collaborative innovation also enables cost, risk, and benefit sharing among collaborators (7). Due to the importance and potential benefits of collaborative innovation, many studies have been conducted in this field, and the trend is growing. Despite the abundance of research literature on collaborative innovation, a comprehensive assessment of collaborative innovation research literature, especially using bibliometric analysis, is relatively scarce. Therefore, this study aims to fill this void by conducting a bibliometric study in the field of collaborative innovation by systematically mapping the landscape of collaborative innovation research and visualizing the research trends based on past literature on this area of study. To guide this study systematically, six research questions were developed for it to answer, which are: 1) what is the current research landscape in the area of collaborative innovation? 2) What is the current publication trend in collaborative innovation research? 3) Which prominent authors, countries, and institutions are spearheading the development of collaborative innovation research? 4) Which articles are the most influential in the area of collaborative innovation research? 5) In which journals were the articles on collaborative innovation published the most? and 6) what are important research trends and clusters behind the development of collaborative innovation research?

## Methodology

This study utilized bibliometric analysis, an approach that assesses and visualizes research output in scientific literature through measurement of the properties of documents (15). In contrast to systematic literature reviews, which qualitatively synthesize studies within a defined context and may be subject to researchers' biases, bibliometric analysis adopts a macro perspective by employing quantitative methods to reveal knowledge patterns across extensive volumes of literature (16, 17). In addition, unlike meta-analyses that utilize statistical evaluation of outcomes related to specific relationships, bibliometric analysis offers a more holistic insight into an area of study (16), making it particularly effective for mapping the landscape of the developing field of collaborative innovation.

This study utilized bibliographic data extracted from the Scopus database as of August 8, 2022. The Scopus database was chosen due to several strategic reasons; among them is the extensive coverage across various academic disciplines and geographical location (18), making it suitable for mapping multidisciplinary research fields like collaborative innovation. Although Google Scholar may possess a larger number of collections, it was not chosen due to its less stringent indexing procedures and difficulty in bibliographic data retrieval (19). In addition, compared to Web of Science, Scopus offers a more inclusive indexing approach, capturing a wider array of subject areas while maintaining stringent quality standards (20). Using the Scopus database, the bibliographic data search strategy was performed based on the modified Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) protocol that is visualized in Figure 1.

Related articles were obtained by using the term "collaborative innovation" in the article title as the primary search field. The focus on the title of articles was made as it is the first element that the readers will observe (21), and it represents and signifies the relevance of the area and aim of the study (22). As this study aimed to visualize the development within this area of research since its beginning, there was no specific time frame of publication date that was set. In addition, the selection of bibliographic data was limited only to journal articles. The exclusion of other types of publications was made because they are less comparable to the double-blind peer reviews by Scopus journals (23). Based on the search strategy, a total of 375 articles were retrieved for the analyses. After the bibliographic data was extracted from Scopus, the data was used to perform several analyses using an Excel spreadsheet and the Biblioshiny application – a web interface for an open-source tool for bibliometric analysis called Bibliometrix (24).
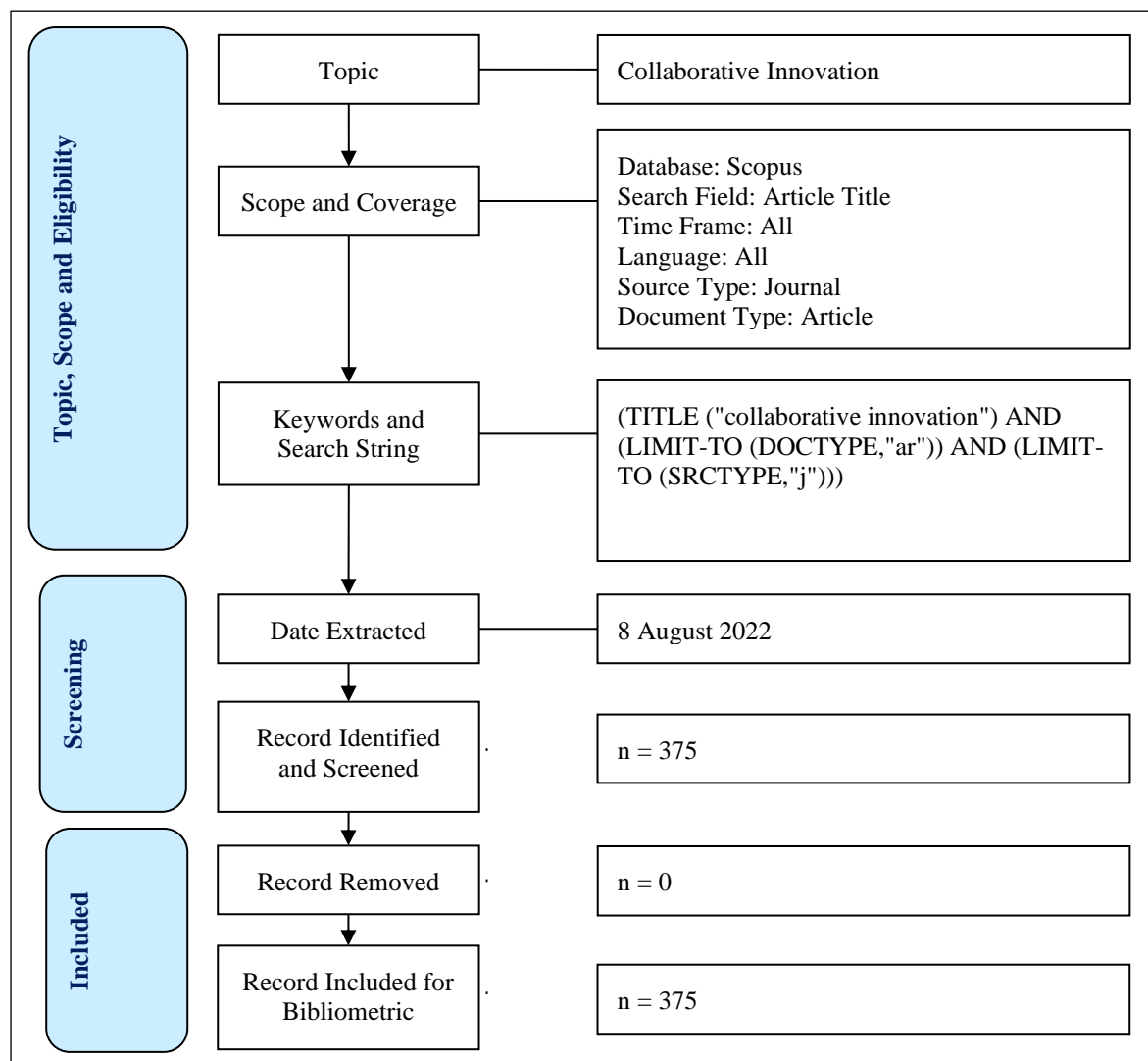
**Figure 1:** Flow Diagram of Search Strategy (24)

Descriptive analysis was done to respond to the first research question until the fifth research question, namely by investigating the current research landscape, publication trend, key contributors, prominent articles, and the most frequent publication source. Meanwhile, keyword analysis and clustering analysis were performed to address the sixth research question, which is to identify trends and knowledge structure, i.e., the hidden pattern behind the selected articles (25). The results and discussions of these analyses can be found in the following section and were made according to the research questions.

## Results and Discussion
### Current Research Landscape

To address the first research question, Biblioshiny was used to extract the main information of selected articles to get an overview of the collaborative innovation research landscape. Referring to Table 1, the first article concerning collaborative innovation was published in 1990. Since 1990 until the date of data extraction, a total of 375 articles have been published in 252 journals. In terms of citation, the average years for an article to be cited were recorded at 4.27, and the average citations per article were at 15.33. This number highlighted the importance and relevance of collaborative innovation research. In addition, a total number of 1,138 keywords have been used by the authors. Meanwhile, in terms of authorship, a total of 893 authors have contributed to the studies on collaborative innovation, resulting in an average of 0.42 documents per author. 47 of the selected articles were published by a single author, and the average number of authors per document stands at 2.38.

**Table 1:** Main Information Regarding Selected Article

| Description | Results |
|---|---|
| **Main Information about Data** | |
| Timespan | 1990:2021 |
| Sources (Journals, Books, etc.) | 252 |
| Documents | 375 |
| Average years from publication | 4.27 |
| Average citations per documents | 15.33 |
| Average citations per year per doc | 2.454 |
| References | 18770 |
| **Document Types** | |
| Article | 375 |
| **Document Contents** | |
| Keywords Plus (ID) | 1313 |
| Author's Keywords (DE) | 1138 |
| **Authors** | |
| Authors | 893 |
| Author Appearances | 1141 |
| Authors of single-authored documents | 44 |
| Authors of multi-authored documents | 849 |
| **Authors Collaboration** | |
| Single-authored documents | 47 |
| Documents per Author | 0.42 |
| Authors per Document | 2.38 |
| Co-Authors per Documents | 3.04 |
| Collaboration Index | 2.59 |

Next, using an Excel spreadsheet, the bibliographic data of the collection was analyzed based on two criteria, namely language and subject area. With regards to language, referring to Table 2, 333 or 88.80% of the selected articles were published in English. 29 (7.73%) of them were in Chinese, and the remaining articles were using either French (9; 2.40%), Spanish (3; 0.80%), or Portuguese (1; 0.27%). This is not surprising, as English is the most prominent language used in research and publications.

**Table 2:** Languages

| Language | Total Publications (TP) | Percentage (%) |
|---|---|---|
| English | 333 | 88.80 |
| Chinese | 29 | 7.73 |
| French | 9 | 2.40 |
| Spanish | 3 | 0.80 |
| Portuguese | 1 | 0.27 |
| Total | 375 | 100.00 |

With regard to subject areas, based on Scopus data, the entire collection of collaborative innovation research has appeared in a total number of 23 subject areas, with 161 or 42.93% of the articles being published in Business, Management, and Accounting, making it the top subject for collaborative innovation discussion. It was followed by Engineering (89; 23.73%), Social Science (89; 23.73%), and Computer Science (87; 23.20%). Other fields of study that contributed quite significantly to collaborative innovation research were Economics, Econometrics, and Finance; Environmental Science; Mathematics; Decision Science; and Energy. Based on Table 3 below, it is notable that this field of study extended into diverse subject areas, highlighting its importance in various disciplines.

**Table 3:** Subject Area

| Subject Area | Total Publications (TP) | Percentage (%) |
|---|---|---|
| Agricultural and Biological Sciences | 4 | 1.07% |
| Arts and Humanities | 4 | 1.07% |
| Business, Management and Accounting | 161 | 42.93% |
| Chemical Engineering | 5 | 1.33% |
| Chemistry | 4 | 1.07% |
| Computer Science | 87 | 23.20% |
| Decision Sciences | 28 | 7.47% |
| Earth and Planetary Sciences | 12 | 3.20% |
| Economics, Econometrics and Finance | 40 | 10.67% |
| Energy | 26 | 6.93% |
| Engineering | 89 | 23.73% |
| Environmental Science | 46 | 12.27% |
| Health Professions | 1 | 0.27% |
| Materials Science | 8 | 2.13% |
| Mathematics | 44 | 11.73% |
| Medicine | 15 | 4.00% |
| Multidisciplinary | 7 | 1.87% |
| Neuroscience | 2 | 0.53% |
| Nursing | 1 | 0.27% |
| Pharmacology, Toxicology and Pharmaceutics | 7 | 1.87% |
| Physics and Astronomy | 6 | 1.60% |
| Psychology | 11 | 2.93% |
| Social Sciences | 89 | 23.73% |
| Total | 375 | 100.00 |

## Publication Trend

To address the second research question, the data were analyzed using Microsoft Excel to visualize annual publication and citation trends, as shown in Figure 2 below. As mentioned previously, the first article on collaborative innovation published in the Scopus was in 1990 (26). Interestingly, there was a two-year gap before the second article (27) and a bigger gap with the third article (28). It was only in 2005 that articles concerning collaborative innovation were published consistently every year.
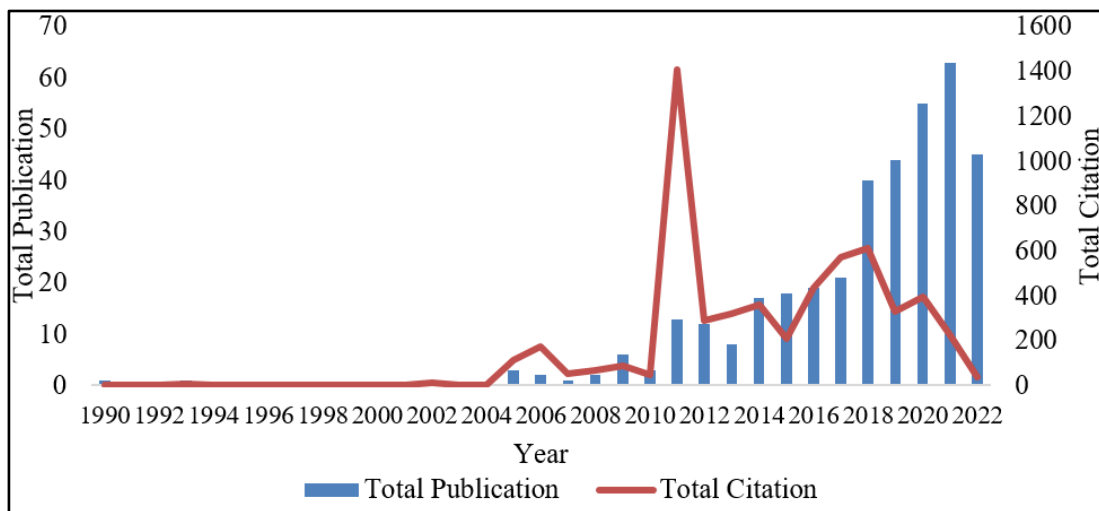


**Figure 2:** Publication Trends

Except for several minor dips in annual total publication, the trend has been upward ever since, especially from 2011 and 2018 onwards. The increase in publication numbers during these two periods signifies the heightened interest in collaborative innovation, which can be attributed to several factors. In the 2011 period, the surge may have been influenced by the rise of digital platforms facilitating global collaboration, an increasing attention towards knowledge economy that emphasize knowledge sharing, and the post-2008 economic recovery that pushed

collaborations among firms (29–31). Meanwhile advancement in digital ecosystems, the emergence of gig economy facilitating talent access, and an increased focus on sustainability fostering cross-sector collaboration may have contributed to the second surge in 2018 (29, 30, 32). Throughout the period from 1990 until the date of extraction, the annual growth rate of total publication was computed at 20.97%. However, in contrast to total publication, the citation trend has not been encouraging. It reached its peak in 2011 with 1,407 total citations, but since then, it has declined, averaging only approximately 375 total citations annually. One probable cause could be the rise of "open innovation", which carries a similar but wider conception of the usage of external resources in innovation activities (12).

## Key Contributors

This study investigated the authors, countries, and institutions that produced the highest number of articles as part of addressing the third research question. Firstly, in terms of authors, the Top 10 most productive authors are shown in Table 4 below. Based on the findings, it was found that the top two most productive authors came from the same institution. Both have published several articles together, and their articles were among the

top-cited documents. In addition, further investigation using the author profile in Scopus indicates that most, if not all of them have contributed to the field of social sciences, including but not limited to business, management, economics, and public administration.

Overall, researchers from 41 countries have contributed to the publication of the selected articles in this field of study. China topped the list, with over half of all publications in the area of collaborative innovation coming from researchers from the country (Table 5). However, when looking at other top countries within the Top 10 most productive countries rankings, Western countries (including Australia) made up the remaining spots. Unsurprisingly, institutions from China have contributed the most, given that researchers from the country produced approximately half of the total publication. Chinese institutions occupy all but two positions in the top 10 most productive affiliations (Table 6), with Harbin Engineering University contributing the most with a total of 14 publications. Furthermore, the inclusion of Roskilde Universitet in Denmark in the ranking is not surprising, given that the institution produces the top two authors.

**Table 4**: Top ten Most Productive Authors

| Author's Name | Affiliation | Country | Total Publications (TP) | Percentage (%) |
|---|---|---|---|---|
| Torfing J, | Roskilde Universitet | Denmark | 7 | 1.87% |
| Sørensen E, | Roskilde Universitet | Denmark | 6 | 1.60% |
| Fan F, | Wuhan University | China | 5 | 1.33% |
| Yang Y, | Chongqing University | China | 5 | 1.33% |
| Wang S. | Northeastern University | China | 4 | 1.07% |
| Wang X, | Wuhan University | China | 4 | 1.07% |
| Berger R, | Bar-Ilan University | Israel | 3 | 0.80% |
| Elert N. | Research Institute of Industrial Economics | Sweden | 3 | 0.80% |
| Frattini F, | Politecnico di Milano | Italy | 3 | 0.80% |
| Hansen T | Københavns Universitet | Denmark | 3 | 0.80% |

**Table 5:** Top ten Most Productive Countries

| Country | Total Publications (TP) | Percentage (%) |
|---|---|---|
| China | 190 | 50.67 |
| United States | 44 | 11.73 |
| United Kingdom | 31 | 8.27 |
| France | 21 | 5.60 |
| Italy | 21 | 5.60 |
| Denmark | 15 | 4.00 |
| Sweden | 15 | 4.00 |
| Netherlands | 13 | 3.47 |
| Australia | 11 | 2.93 |
| Norway | 11 | 2.93 |

**Table 6:** Top 10 Most Productive Institutions

| Affiliation | Country | Total Publications (TP) | Percentage (%) |
|---|---|---|---|
| Harbin Engineering University | China | 14 | 3.73 |
| Roskilde Universitet | Denmark | 9 | 2.40 |
| Tsinghua University | China | 8 | 2.13 |
| Wuhan University | China | 8 | 2.13 |
| Zhejiang University | China | 7 | 1.87 |
| Harbin Institute of Technology | China | 7 | 1.87 |
| Wuhan University of Technology | China | 7 | 1.87 |
| Shanghai Jiao Tong University | China | 6 | 1.60 |
| National University of Singapore | Singapore | 5 | 1.33 |
| Nanjing University of Aeronautics and Astronautics | China | 5 | 1.33 |

## Highly Cited Articles

This study performed an analysis based on the total number an article received, both in terms of local citation and global citation. The former refers to the total citations a document received from other articles within the dataset, i.e., the collection, while the latter represents the number of citations an article received from the entire database, in the case of this study, the Scopus database (25, 33). However, to address the fourth research question, which is to investigate the most prominent articles that influenced the development of collaborative innovation research, this study ranked the articles based on local citation. The local citation signifies the intellectual base within the specific area of research, whereas an article with a higher global citation indicates a greater interest from multidisciplinary community compared to other articles (34). It was for this reason that this study

ranked the collection based on local citation, as it enabled this study to identify articles with the most impact within the collaborative innovation research.

Based on the analysis, Table 7 below summarizes the findings for the top 10 most cited articles in this field. As mentioned in the previous section, the top two most active authors have co-authored several top cited articles together. This is evidence that both are the "go-to researchers" in this field, especially when it concerns collaborative innovation in the context of public administration and government. In addition, it is also interesting to see that all except one article were published from 2011 onward, further strengthening the fact that this field of study only started receiving attention slightly more than a decade ago. Upon examining the titles of the top cited articles, it is evident that the majority of them fall within the social science field.

**Table 7:** Top 10 Highly Cited Articles

| Authors | Title | Year | Local Citations | Global Citations |
|---|---|---|---|---|
| Sørensen E, Torfing J. | Enhancing Collaborative Innovation in the Public Sector (35) | 2011 | 28 | 389 |
| Baldwin C, von Hippel E. | Modeling a Paradigm Shift: From Producer Innovation to User and Open Collaborative Innovation (36) | 2011 | 27 | 610 |
| Hartley J, Sørensen E, Torfing J. | Collaborative Innovation: A Viable Alternative to Market Competition and Organizational Entrepreneurship (37) | 2013 | 19 | 303 |
| Najafi-Tavani S, Najafi-Tavani Z, Naudé P, Oghazi P, Zeynaloo E. | How collaborative innovation networks affect new product performance: Product innovation capability, process innovation capability, and absorptive capacity (38) | 2018 | 11 | 177 |
| Davis JP, Eisenhardt KM. | Rotating Leadership and Collaborative Innovation: Recombination Processes in Symbiotic Relationships (39) | 2011 | 11 | 294 |
| Swink M. | Building Collaborative Innovation Capability (40) | 2006 | 11 | 140 |

| Authors | Title | Year | Local Citations | Global Citations |
|---|---|---|---|---|
| Wang F, Hu Q. | Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance (41) | 2020 | 10 | 83 |
| Fawcett SE, Jones SL, Fawcett AM | Supply chain trust: The catalyst for collaborative innovation (42) | 2012 | 8 | 164 |
| Sørensen E, Torfing J. | Metagoverning Collaborative Innovation in Governance Networks (43) | 2017 | 7 | 86 |
| Crosby BC, 't Hart P, Torfing J. | Public value creation through collaborative innovation (44) | 2017 | 7 | 146 |

## Most Frequent Source Title

In response to the fifth research question, Table 8 details the Top 10 most frequent source titles that published articles in the collaborative innovation area. Two journals, Sustainability Switzerland and Mathematical Problems in Engineering, stood out significantly, with the former having the highest number of 12 articles, or 3.20%, and followed by the latter with 10 (2.67%) articles from the collection. All other journals meanwhile only published five articles or less. In addition, based on the title of the journal, it is found that most of the articles were published in innovation, business, social science, and engineering related journals.

**Table 8:** Top Ten Most Frequent Source Title

| Journal Title | Total Publications (TP) | Percentage (%) |
|---|---|---|
| Sustainability Switzerland | 12 | 3.20 |
| Mathematical Problems in Engineering | 10 | 2.67 |
| Creativity And Innovation Management | 5 | 1.33 |
| Discrete Dynamics in Nature and Society | 5 | 1.33 |
| Innovations | 5 | 1.33 |
| Jisuanji Jicheng Zhizao Xitong Computer Integrated Manufacturing Systems CIMS | 5 | 1.33 |
| Journal Of Cleaner Production | 5 | 1.33 |
| Technological Forecasting and Social Change | 5 | 1.33 |
| European Journal of Innovation Management | 4 | 1.07 |
| IEEE Transactions on Engineering Management | 4 | 1.07 |

## Key Research Keyword and Cluster

In response to the final research question, which is "What are important themes behind the development of collaborative innovation research?" this study conducted two types of analyses: keyword analysis and clustering analysis. With regards to the former, it was conducted through word cloud and topic trends using the Biblioshiny application. It was performed based on the number of occurrences of keyword plus and the year of their occurrence (for topic trends only). In this keyword analysis, instead of the author's keyword, keyword plus was utilized, as it enables the capture of the content of an article with greater depth and variety (45).

The word cloud was used to visualize the most frequent keyword used within a specific dataset (25), in this case, the collection of collaborative innovation research articles. The size of the word indicates its frequency, therefore, the bigger the word is, and the more frequent it appears in the collection. Based on the word cloud, whose output is shown in Figure 3 below, among the keywords that frequented the most within the collaborative innovation related articles were "innovation," "China," "knowledge management," "human," and "decision making". It is also noteworthy that, from the keyword, collaborative innovation research attracts multidisciplinary attention, ranging from logistics, medicine, business, and management to science and technology. Looking from other perspectives, this area of study also attracted several stakeholders, such as industry, government, societies, organizations, and individuals.

**Figure 3**: Word Cloud Based on Most Frequent Keyword Plus

However, using the word cloud alone did not provide the information relating to the evolution of the term used in the area of study. In identifying the period in which the keywords were used, topic trend analysis was performed. Instead of just focusing on the frequency, this analysis focused on the development of the keywords, namely by capturing the year of their first appearance, the final year they were used, and the median year. At the median year, there is a bubble that indicates the keywords' frequency, with a bigger bubble indicating a more frequently used keyword (25). The findings of topic trend analysis can be found in Figure 4.
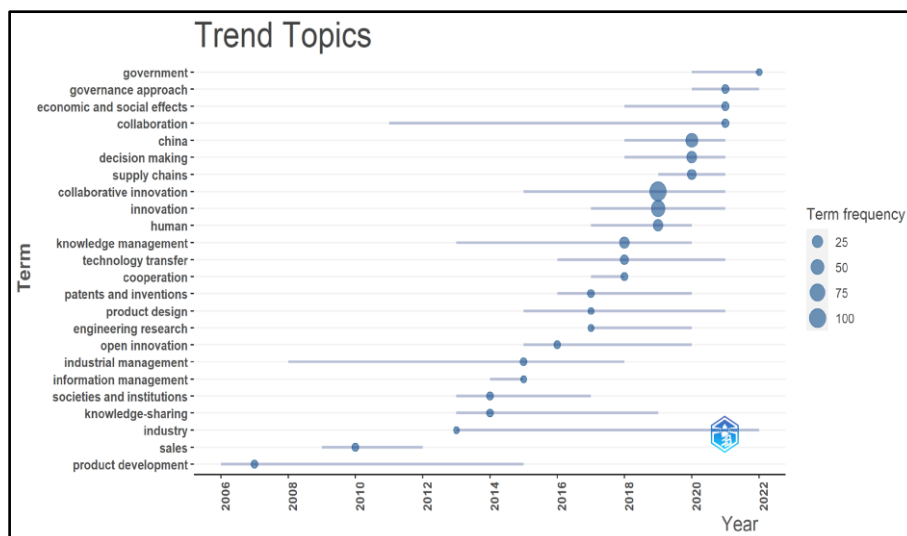


**Figure 4:** Trend of Keyword Plus

Figure 4 above illustrates the evolution of various keywords from 2006 until 2022. For instance, terms such as "sales", "product development" and "industry" were more prominent in earlier periods but have seen a decline in frequency relative to more recent terms. This may indicate an initial emphasis on leveraging collaboration in innovation efforts among industry players to enhance product design, improve market competitiveness, and facilitate rapid commercialization, which directly associated with sales growth and product development processes. However, as this field matured, the focus shifted to include more complex and systemic dimensions within the collaborative innovation framework. Consequently, previous prevalent keywords were overtaken by concepts such as "open innovation", "knowledge management", "supply chain", "economic and social effects" and "governance approach", which emphasize strategic collaboration, intellectual capital, and governance to support firm

competitiveness through long-term competitiveness and sustainability of organizations. Additionally, Figure 4 indicates that keywords such as "governance approach" and "government" have emerged as the most recent keywords with a notable frequency of occurrences, implying public sector and governance-related topics are currently central to the discourse in the field of collaborative innovation. This finding aligns with recent studies that highlight the increasing collaborative involvement of external stakeholders in public sector innovation (46, 47). While the objectives of their studies may differ from this study, such as investigating the impact of citizen involvement in public sector innovation (46) and identifying external collaborators in this domain (47), both studies nevertheless concur on the increasing focus on collaborative innovation within the public sector. The recent increase in interest in this area may be attributed to citizen demand (46) and the pressing external and organizational challenges (47) that highlight the need for innovative solutions.

In addition, this study also conducted a clustering analysis, performed using the Biblioshiny application, in order to identify the knowledge

structure, i.e., the hidden pattern within the selected articles (25). By grouping data points that share similar characteristics and assigning them to clusters (48), publications related to collaborative innovation could be further categorized into several areas of study. Clusters were delineated by analyzing the shared references among the dataset of collaborative innovation articles. The output therefore would generate clusters of articles that share a common reference, indicating thematic similarity among them (25, 49, 50). The boundaries of each cluster were subsequently refined by identifying a common theme through qualitative analysis of the abstracts and keywords. The result of clustering analysis is visualized in a coupling map as shown in Figure 5 below, with the x-axis indicating the level of centrality, i.e., the importance of a cluster in the whole collection, and the y-axis referring to the cluster impact, which is based on a normalized citation score (25, 51). Based on the clustering analysis, five clusters have been identified. Out of these five clusters, two demonstrated a high level of centrality, indicating their significance within the research field. The following discussion would focus on these two clusters.
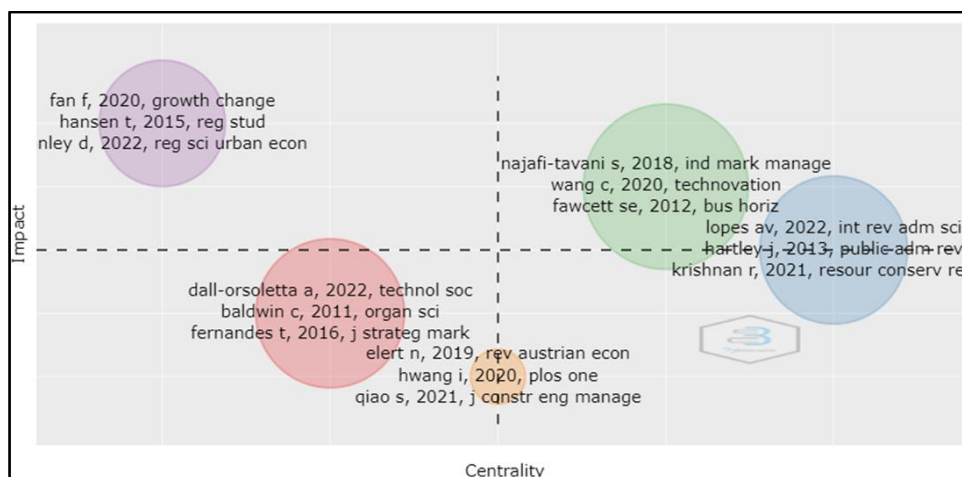


**Figure 5:** Cluster by Documents Coupling Map

The first one, the blue cluster, has shown the highest level of centrality among all clusters. It mostly consists of articles concerning collaborative innovation in the context of public sector and government. The pattern of publications in this cluster followed a similar growing trend in Figure 2, with all but three articles published from 2011 onward. The top 3 most cited articles in this cluster received

approximately half of the cluster's total citation, and all of them discussed the conceptualization of collaborative innovation as a public innovation strategy. Sørensen and Torfing (35), the most cited as well as the earliest among the three, attempted "to advance collaborative innovation as a new, interdisciplinary research field" by discussing the theoretical development of collaborative innovation and presented an

analytical model for collaborative innovation in the public sector (52). Hartley, Sørensen and Torfing, meanwhile, compared collaborative innovation with two other public innovation strategies for enhancing the public sector (37). As for Crosby, Hart and Torfing, the authors discussed how collaborative innovation in the public sector could create public value, as well as examined the type of leadership needed to foster collaborative innovation (44). Interestingly, all three top cited articles in this cluster were authored by Jacob Torfing, the top author for the whole collection. Compared to the first blue cluster, the green cluster has a slightly higher level of impact but with less centrality within the collaborative innovation research field. A huge difference from the blue cluster is that this cluster focuses on collaborative innovation within private firms. For instance, the subjects of top-cited articles in this cluster were from computing and communication, manufacturing, and service industry. From the abstract, it also could be noticed that these articles discussed collaborative innovation in relation to either supply chain, innovation capability, innovation performance, or a combination of these. Contrasting to the blue cluster, all the top three most cited in this cluster were performed and based their conclusions on empirical results.

The other three clusters, meanwhile, have shown a moderate (orange cluster) and low level of centrality (purple cluster and red cluster). The orange cluster consists only of ten (10) articles; therefore it is the smallest bubble. All but one article within this cluster were published within 2018 to 2021, with discussion about collaborative innovation taking place from various perspectives, ranging from the construction industry, information and communication technologies, and economics. The red cluster, meanwhile, covered collaborative innovation in relation to topics such as co-creation, marketing, and product innovation. Albeit recording the highest level of impact, articles within the purple cluster have the least importance within this research field. The articles within this cluster discussed collaborative innovation from the perspective of economics.

## Conclusion

This study was conducted to provide insights on

the landscape and trends relating to collaborative innovation research. To achieve this aim, bibliographic information of 375 relevant articles was extracted from the Scopus database and used for bibliometric analysis. From the analysis, publication trends, prominent key contributors, and landmark articles and sources were identified. This information could be useful for future researchers in collaborative innovation research for their source of reference, collaboration, and networking, as well as for identifying future research direction and opportunities.

In addition, keyword analysis via word cloud and topic trends were performed using the Biblioshiny application. From the output of these analyses, key themes based on keywords from the current collaborative innovation studies and future research directions can be identified. For instance, as "government" and "economic and social effects" have emerged as on-going keyword trends, and the public sector has also shown the highest level of importance within collaborative innovation, future research could focus on collaborative innovation relating to sustainability within the context of the public sector. This particular area, particularly circular economy (CE)-oriented innovation, has gained traction lately but is primarily explored in the context of the private sector, therefore opening huge opportunities to scholars to investigate this niche area in the public sector. One exception is a study by Clifton, Kyaw, Liu and Walpole; however, their investigation is confined to motivations and constraints in CE-oriented innovation within the Welsh public sector (53). As such, future studies may explore other aspects of CE-oriented collaborative innovation in the public sector, such as the effect of collaborators and the impact on public sector performance.

This study has several limitations, including its reliance on the Scopus database as the sole bibliometric data source, potentially omitting impactful studies from other databases. Future bibliometric studies on this topic should incorporate sources from other prominent databases, such as Web of Science. Another limitation is the search strategy, as this study only used one specific term in the article's title. Future studies may expand the terminology used during the search process and incorporate it into

additional search fields. Additionally, the nature of bibliometric analysis itself has methodological constraints stemming from its dependency on metadata and its quantitative evaluation. For instance, the citation-based metrics may be affected by factors unrelated to research quality, such as self-citations or publication age (54). Furthermore, while bibliometric analysis provides a quantitative view on research trends, it is deficient in depth and qualitative insights into methodologies and findings of studies (17). In this regard, it is advisable to supplement bibliometric analysis with content analysis, or systematic review of literature, to achieve a more content-driven and rigorous synthesis of literature, thus providing a thorough understanding of the collaborative innovation field.

## Abbreviation

Nil.

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Nil.

## Author Contributions

Mohd Uzairi: Conceptualization, Methodology, Formal analysis, Investigation, Writing Original Draft. Mohd Rizal: Writing, Reviewing and Editing, Supervision. Yuhainis: Supervision.

## Conflict Of Interest

None.

## Ethics Approval

Not Applicable.

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